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Problem-based learning in dental education: what's the evidence for and against . . . and is it worth the effort?

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Abstract

All Australian dental schools have introduced problem-based learning (PBL) approaches to their programmes over the past decade, although the nature of the innovations has varied from school to school. Before one can ask whether PBL is better than the conventional style of education, one needs to consider three key issues. Firstly, we need to agree on what is meant by the term PBL; secondly, we need to decide what "better" means when comparing educational approaches; and thirdly, we must look carefully at how PBL is implemented in given situations. It is argued that PBL fulfils, at least in theory, some important principles relating to the development of new knowledge. It also represents a change in focus from teachers and teaching in conventional programmes to learners and learning. Generally, students enjoy PBL programmes more than conventional programmes and feel they are more nurturing. There is also some evidence of an improvement in clinical and diagnostic reasoning ability associated with PBL curricula. The main negative points raised about PBL are the costs involved and mixed reports of insufficient grounding of students in the basic sciences. Financial restraints will probably preclude the introduction of pure or fully integrated PBL programmes in Australian dental schools. However, our research and experience, as well as other published literature, indicate that well-planned hybrid PBL programmes, with matching methods of assessment, can foster development of the types of knowledge, skills and attributes that oral health professionals will need in the future.

Key words: Problem-based learning, dentistry, Australia, challenges.

Abbreviations and acronyms: MEQs = modified essay questions; OSCAs = objective structured clinical assessments; PBL = problem-based learning; TJs = triple jumps.

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INTRODUCTION

Over the past 10 years or so, all of the dental schools in Australia have introduced problem-based learning (PBL) approaches to their programmes. The pressures for change have included dissatisfaction of students with the conventional model of dental education, a desire by dental academics to implement new educational approaches that are more student-centred, and a need to meet the requirements of the accreditation process of the Australian Dental Council. The nature of the PBL components introduced has varied from school to school. In some there is a PBL philosophy running throughout the entire programme, whereas in others, individual courses or subjects are presented in a PBL format but the rest of the programme is presented in a more conventional, lecture-based style.

A common question raised by academics, clinicians and students about PBL is "Is it any better than the conventional style of dental education?". Although this may seem to be a justifiable question, there are several reasons why any response needs to carry with it a number of provisos and qualifications. There are at least three key issues that need to be considered before one can hope to compare the "effectiveness" of PBL with conventional approaches to dental education.

Firstly, we need to agree on what is meant by the term PBL. As Herreid[1] has pointed out, the term has been used to mean so many different things that it has almost become useless. Maudsley[2] has provided some useful "ground rules" in describing PBL and contends that it is both a method and a philosophy and that it should be curriculum-wide and supported by all curricular elements.

Secondly, how should one define "better" when comparing different educational approaches? What types of outcomes do we need to define and how should they be measured or assessed? Furthermore, from whose perspective should we view the issue – from the viewpoint of students, academic staff, employers, or the public? And is it really feasible to make truly objective comparisons between different educational approaches, considering the complexities of educational settings?[3,4]

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Thirdly, we must look carefully at the way in which PBL is implemented in a given situation when trying to evaluate its effectiveness. In other words, what are the practical issues, as distinct from the philosophies, that can affect outcomes. This includes, for example, the quality of induction courses in PBL provided for students, how much staff support is available, how many students are involved in group activities, and the appropriateness of the physical facilities. Just as we have all experienced "good" and "bad" lectures, there can also be "good" and "bad" PBL. This may not necessarily reflect inherent problems with the educational approach but rather with how it has been implemented and presented.

Each of these issues will be considered in this review, drawing on our own research and experience, as well as other published literature, to provide a view of where we have come from, where we are at present, and how PBL might fit within the Australian dental education scene in the future.

What do we mean by PBL?

Some claim PBL is merely a variant of case-based education that has been around for thousands of years.[1] Although this claim is debatable, PBL was introduced in its modern form at McMaster University Medical School in Canada in the 1960s, so it is by no means a "recent" educational innovation in the health professional field. However, it is important to realize that PBL is not the same as problem-solving. Inman[5] has contrasted these approaches nicely by pointing out that "One (problem-solving) leads to a solution but not necessarily to understanding; while the other (PBL) leads to understanding but not necessarily to a solution".

PBL, as applied in Adelaide, is an educational approach in which groups of students are involved in a range of activities during and outside of classes. During PBL tutorials, students systematically analyse realistic, professionally relevant situations, often involving patients, to identify "gaps" in their understanding. They research these "gaps" and participate in other classes, e.g., class meetings, learning laboratories and/or clinical practice before returning to their PBL tutorial to review and apply their learning to the situation under discussion. These situations provide a stimulus, context and organizer for our students' learning. The key features of PBL are that the problem comes first before any formal study or reviewing of relevant literature, the learning programme is student-centred, i.e., students are involved in deciding what and how they will learn guided by a facilitator, and the learning takes place in small groups.[6] There is a series of steps involved in working through a typical PBL package and these are summarized in Table 1.

Drawing on the thoughts of Barrows,[7] we believe that the three key educational objectives of PBL are as follows: (1) To assimilate new knowledge that is integrated from different disciplines and structured to facilitate recall and application into a pre-existing conceptual framework; (2) To develop a systematic approach to analysis of clinical situations, to develop the ability to evaluate one's own performance and that of others, and to develop good team and interpersonal skills; (3) To develop self-directed learning skills, as well as the skills and behaviours to continue to learn.

Table 1. Steps in working through a typical PBL package

A typical PBL package consists of the following:

1. Students are presented with a realistic scenario, perhaps with a video trigger, simulated or real patient, that is designed to draw on prior knowledge but is presented "up-front" prior to formal study of the new topics raised in the scenario.
2. Students work in small groups with a facilitator to clarify terms and concepts, analyse and interpret the situation and identify the issues and problems presented in the situation.
3. The group of students generates working hypotheses about the possible causes and consequences of the identified problems and indicates what additional information is required to assess if their hypotheses are likely and explain what is going on, and to respond to or manage the situation.
4. The group identifies questions arising from the scenario (referred to as learning issues) that it needs to explore and members go away and undertake self-directed learning, together and on their own.
5. Students return later to share their learning experiences, to clarify their explanations and response to the situation, and apply their learning to their analysis and reasoning about the situation, e.g., explaining risks, causes and outcomes about the patient's problems, making a diagnosis, and/or developing a management plan. More information may be provided by the facilitator leading to a further iteration of the process.
6. The problem is concluded with a review of the students' current understanding and abilities, with integration of learning achieved through their problem exploration and independent study.

PBL contrasts with conventional approaches to dental education that are usually teacher-centred rather than student-centred. Conventional curricula tend to be characterized by large numbers of lectures delivered by staff from the front of a lecture theatre with limited student interaction. Each discipline is generally taught and assessed separately and there is minimal integration or coordination between them – this is left to the students[8] to develop sometime between graduation and commencement of practice (or later). Usually the basic sciences are taught first, followed by clinical subjects in later years. Examinations tend to focus on, and often reward, the detailed recollection of facts, commonly with little requirement for application of knowledge in authentic or relevant situations or demonstration of real understanding.

In PBL programmes, academics act as facilitators of learning and interact more closely with small groups of students. By their design, the problems encourage a multidisciplinary approach and the need to apply knowledge in particular situations. In broadly contrasting PBL and conventional curricula, we acknowledge that there can be considerable variation within each and so any comparisons need to be made with considerable caution.

PBL fulfils, at least in theory, three important principles relating to the development of new knowledge; namely, activation of prior knowledge,

encoding specificity and elaboration of knowledge.[9-11] It is proposed that current learning is affected by past learning, so educational approaches should aim to activate prior learning. Encoding specificity refers to the way in which information is stored and retrieved from memory. Two aspects of encoding specificity are context specificity and processing specificity.[11] The former means that the more similar the learning situation is to the situation in which knowledge needs to be applied, the more likely that the learning will be transferred. The latter term refers to the concept that the way in which information is processed and stored in memory influences how well it can be retrieved subsequently.[12] Elaboration of knowledge means that information tends to be better understood and remembered if there is opportunity for elaboration, including discussion and explanation of concepts. As can be seen, the structured approach to working through PBL packages fits well with these educational principles, but the question often raised is, "Does PBL work in practice and is it worth the effort?".

Whether PBL is a better educational approach or not, it certainly represents a change in focus from teachers and teaching in conventional programmes to learners and learning. We believe strongly that this is a definite advance in dental education. Associated with this more student-centred focus, PBL programmes create an environment where students need to become responsible for their own learning from early on. PBL also reinforces the concept that knowledge should not just relate to knowing facts, often referred to as content knowledge, but also to knowing why, how and when, so-called process or conditional knowledge.[8,13] Again, in our opinion this is a very desirable feature to emphasize in dental curricula. The emphasis is on being an active, responsible participant in one's education rather than being a passive recipient of information.

Pure or "authentic" integrated PBL programmes, as defined by Barrows,[14] involve virtually no lectures at all, with small groups of six to eight students working through a series of PBL packages, assisted by a facilitator who is not necessarily an expert in the areas of study. The proponents of this approach are sometimes thought of as the "purists" or "zealots" and they tend to frown upon the many variations of PBL that have arisen over the years. There are relatively few of these pure programmes in existence anymore – even McMaster, the home of PBL, includes some lectures in its programme. Perhaps the closest examples in dentistry are those running at the Universities of Southern California,[15] Malmö[16] and Hong Kong.[17]

A major issue when considering the pure form of PBL, with approximately one facilitator per six to eight students, is cost. However, analysis of costs for a well planned and balanced programme has shown that pure PBL need not necessarily involve greater time commitment than more conventional methods of teaching.[18,19] Mennin and Martinez-Burrola[18] showed staff in a PBL programme spent more time with students (72 per cent compared with 39 per cent) and less time in preparation (28 per cent compared with 61 per cent) by comparison with a conventional curriculum. However, Herreid[1] raises the issue of cost in considering PBL in medical education and claims that in the USA "the reward system is not geared to educating medical students". He contends that the focus on winning research grants and treating patients, with limited recognition of excellence in teaching, leads to academic staff being reluctant to invest time and energy into PBL. Herreid[1] also suggests that staff tend to suffer burn-out after the initial introductory phase and then opt out, leading to the need to find replacements in an environment where there are already severe shortages of suitably qualified people. These problems are certainly relevant in the Australian dental education context, with the majority of the dental schools being located within "research-intensive" universities in which the major focus is on research activities, particularly related to knowledge creation. These issues are further compounded by limited opportunities for teaching development of existing staff and difficulties in providing appropriate physical facilities and learning resources.

There are various hybrid versions of PBL in dental education, including the Bachelor of Dental Surgery (BDS) and the Bachelor of Oral Health (BOH) programmes at The University of Adelaide, that consist of a combination of both PBL packages and more conventional lectures supported by learning laboratories, tutorials, online modules and resources and clinical practice. Very importantly, as far as we are concerned, there is an overriding PBL philosophy running throughout the Adelaide curricula and the packages are chosen to drive the curriculum and coordinate with topics across the other major streams. There is also early exposure of students to clinical dentistry in the Adelaide programmes and the packages are developed so that the student is placed in the relevant professional role, for example as a dentist or dental therapist/hygienist. While some of the lectures in the Adelaide programmes follow a conventional format, the development of interactive sessions, referred to as class meetings, has been emphasized. These sessions provide a relevant context for active student learning and enable key issues to be reviewed and discussed, rather than merely serving as a means of providing factual information. The different types of learning opportunities presented in the Adelaide programmes provide students with a range of activities and formats.

Another form of hybrid model described by Fincham and Shuler[6] is the "horizontal hybrid" model that involves a pre-clinical component in the first few years followed by a clinical component in the later years. We agree with Fincham and Shuler[6] that a disadvantage of this model is the loss of integration between the basic sciences and clinical practice. Other hybrid models include combining dental students with medical

students in the early years and using packages developed for medicine, perhaps with some modification to emphasize dental relevance. Examples of this approach include existing programmes in Sydney,[20] Harvard,[21] British Columbia[22] and Manchester.[23] Such models may be more economical and may strengthen the background of dental students in medicine but there can be difficulties in ensuring context specificity of the PBL packages, one of the key principles of PBL.

Another possible model is to present PBL within a single subject or segment of a curriculum but it can be difficult to achieve the aims of PBL if it is run as a separate component within a conventional programme. Students tend to receive mixed messages,[24] key issues necessary for positive outcomes from PBL often are not addressed (e.g., introducing students to PBL),[25,26] graded assessments in other courses are the focus of student activity, resulting in delays in their PBL research[25] and staff involved in the conventional component may not support or may even undermine the PBL initiative. Students, like the rest of us, will generally choose the easiest option if given a choice, and many will prefer to sit passively in a lecture theatre rather than actively participate in a group discussion. Michael Burrow recently reported on his attempts to present the subject Dental Materials Science in a PBL mode within the traditional Bachelor of Dental Science (BDSc) programme at The University of Melbourne.[27] He found that the students wanted more lectures and guidance, and did not enjoy learning in small groups. It was concluded that PBL did not work well in this subject within a conventional curriculum.

In considering different models of PBL, assessment is a critical aspect to consider. As in any educational context, the methods of assessment need to match the PBL educational philosophy[8] if there is to be any hope of achieving desired outcomes. Various forms of assessment have been developed for PBL curricula including triple jumps (TJs), objective structured clinical assessments (OSCAs) and modified essay questions (MEQs). These methods attempt to provide feedback to staff and students about a range of attributes, not just recall of facts. More details of these methods of assessment have been provided elsewhere.[28] PBL also focuses on the importance of reflection and so journals of reflection and self-assessment practices should play a central role in assessment of these programmes, whether they are pure, hybrid or presented as single components.[8,29,30]

Hughes and Wood[31] acknowledge the difficulties in changing to PBL and suggest that "conversion to PBL does not have to be 100%". While we agree that PBL does not need to be all or nothing, we are sceptical about the value of choosing those bits and pieces that are thought to be best and implanting them into conventional curricula. We believe that well-planned and integrated hybrid PBL programmes, adapted to take account of the local situation,[8] are likely to be most appropriate, given our circumstances in dental education at present and probably for the medium-term future. We agree with Maudsley[2] that before a programme or course can be referred to as PBL, it should be a curriculum-wide method and philosophy that is supported by all curricular elements. If it is not, then it is probably not appropriate to even consider using a "partial" PBL model for evaluating the effectiveness of PBL, particularly in terms of comparing with other approaches.[3]

Is PBL "better" and what do we mean by "better"?

As was pointed out at the beginning of this review, unless we can agree on the meaning of "better" in an educational setting, this type of question is unlikely to be very helpful. In the past, quantitative measures have been used to compare groups of students from PBL and conventional programmes, e.g., based on their results in board examinations or tests.[32-34] However, board-style examinations often consist of multiple-choice questions that focus mainly on factual knowledge, often unrelated to relevant contexts, so they do not address application of learning in context and the many other desirable attributes of an oral health professional or other curricula outcomes.

There have been four major reviews of the effectiveness of PBL over the past decade and the conclusions have been reasonably consistent.[19,35-37] The main negative point raised about PBL programmes compared with conventional lecture-based approaches relates to the cost of implementation and, depending on class size, maintenance. It could be an expensive exercise to introduce and then provide ongoing support for an entirely new, integrated PBL programme based on the original medical model of six to eight students per facilitator, especially as class sizes increase, although costs for class sizes between 40 to 100 students may not differ greatly.[19] The reported neutral cost of this model of PBL is predicated on including preparation for classes in calculations of time staff spend on teaching.[18] However, many existing PBL programmes in dentistry, nursing and other professions have never had the luxury of groups of six to eight students/faciliator and have needed to develop approaches based on larger group sizes.[26,38,39] Evaluations of these modified programmes confirm that they can be effective[26,39,40] and need not necessarily involve significant additional funding.

The published literature provides some evidence for both desirable and undesirable outcomes from PBL programmes compared with conventional ones, but the differences in both cases are certainly not major. Generally, students enjoy PBL programmes more than conventional programmes and feel that they are more nurturing.[19,35,41] This has been our experience in the Adelaide Dental School[42,43] and similar outcomes have been reported at other dental scschools.[16,22] We agree with Albanese[44] and argue that if this were the only benefit of PBL it would be worthwhile, provided that

Table 2. PBL problem investigation compared with the management of a patient in the clinic

Step	DLP investigation steps	Clinic steps with patient
1.	Video, text, and/or image presented	Patient presents
	Summarize and interpret situation	Summarize history, examination data
	Create problem/issue list	Create problem list
2.	*What is going on here?* Develop causal hypotheses for problems	Develop provisional diagnoses ("diagnostic sieve")
	What might happen? Develop consequential hypotheses for problems	Develop provisional treatment needs
3.	Identify further information needed to test reasoning and hypotheses e.g. • patient information • tests • modifying factors	Obtain further information e.g. • further tests, radiographs • consultations
4.	Identify learning issue questions	Identify further research needed e.g. • unfamiliar condition • new treatment options
5.	Research and apply learning to case	Analyse further research, test results
	Decide if causes and consequences are relevant for patient/situation	Refine diagnosis and prognosis Develop definitive diagnosis
	Respond to the situation	Treatment plan/Review Obtain consent
6.	Reflection and evaluation of PBL package investigation, learning, and group-work • what did I do well and why? • what needs improvement and how will I improve?	Reflection and evaluation • what did I do well and why? • what needs improvement and how will I improve?

the financial and resource implications were not too great.

There is evidence of a small but significant improvement in clinical reasoning or diagnostic ability associated with PBL curricula[45,46] but these findings and their interpretation remain controversial. Debate continues about whether PBL leads to students being able to reason like clinicians and whether it is possible to learn general, transferable problem-solving skills. Hmelo and Lin[47] propose that each of the steps in PBL provide explicit opportunities for students to develop self-directed skills in clinical decision-making. The links between the PBL process and the approach to managing a patient in the clinic are emphasized in the Adelaide Dental School and they are summarized in Table 2. Ensuring that the PBL approach is transferred from the classroom to the clinic[48] remains a major challenge to those of us involved in PBL programmes.

The results of a meta-analysis review of the literature led Albanese and Mitchell[19] to conclude that PBL students tended to study differently to students in conventional programmes. They were more likely to study for understanding rather than for short-term recall and were more likely to use library resources to study. A more recent review of research relating to students' learning processes showed that students in PBL programmes were more likely to plan and undertake research in their own time using resources that they had identified themselves rather than those identified by staff.[49]

Balanced against these apparent benefits of PBL are some reports that students in PBL programmes may not develop sufficient "cognitive scaffolding" in the basic sciences.[19,35,37] However, there is debate about the practical significance of these results and a recent meta-analysis indicated that PBL students have better skills in applying their knowledge.[37] Preliminary findings about perceptions of clinical training directors or managers about basic science knowledge of interns from the hybrid PBL medical curriculum in Sydney was mixed.[50] Evaluation of further cohorts is needed before firmer conclusions are possible.

Even strong proponents of PBL acknowledge that it does not seem to lead to marked differences in cognitive outcomes.[3] Indeed, Norman and Schmidt[3] say that they "believe that PBL has been oversold by its advocates, promising enormous benefits and largely ignoring the associated resource costs".

Colliver[36] claims that the theory underlying PBL is weak and that its theoretical concepts are imprecise. Norman and Schmidt[3] take the opposite view and argue that more, not less, theory-based educational research is needed. They agree with Colliver that "we should rethink the promise of PBL for the acquisition of basic knowledge and clinical skills", but they assert that PBL does provide "a more challenging, motivating and enjoyable approach to education". They stress that evaluations at a curriculum level are unlikely to be useful on their own in determining the effectiveness of PBL but that systematic approaches to research also are needed that include theory building and testing.

We agree with Norman and Schmidt[3] that educational studies that try to compare different approaches at a curriculum level are inappropriate because of the impossibility of controlling for all the factors involved. Often students are selected into PBL programmes using different criteria than those applied to conventional programmes, e.g., with psychometric tests and structured interviews, in addition to academic results. These additional criteria aim to select students who will perform well in PBL programmes, so there is a bias in study samples from the beginning. One also needs to consider the Hawthorne effect associated with new programmes, whereby the initial enthusiasm associated with a new initiative often rubs off on the students but may diminish over time. The assessment format used in comparative studies also impacts on the outcomes related to students' performance.[37]

While the various pros and cons of PBL have been debated in each of the Australian dental schools over the past decade, some of the negative views expressed would appear to have been unfounded. For example, it was claimed that PBL would limit the amount of clinical time available for students and others have raised concerns about a lack of familiar structure.[51,52] There is

no reason why PBL programmes should lead to a reduction in clinical exposure for students. The development of clinical skills by students remains a critical element of any PBL dental programme. In fact, we believe it is desirable for students to begin their clinical practice early and for PBL and clinical components to be closely linked. Clinical activities include both simulated and actual experience. PBL packages can be used to introduce the need to learn about different skills and then students participate in simulated activities related to the patient/situation under discussion. In the clinic, Adelaide students are encouraged to manage their patients in the same way as they would work through a PBL tutorial (refer to Table 2 for parallel steps). As for the allegation that PBL is unstructured, even a cursory scan of texts on planning and running PBL programmes will confirm that this educational approach is highly structured. Furthermore, it requires very careful definition of learning outcomes and formulation of assessment methods that are generally much more transparent and defensible than those associated with conventional programmes.

Some who have experienced a conventional style of dental education may claim, "I turned out OK, so my education can't have been that bad!". We agree that dental education in Australia has maintained a high international reputation for many decades, but most of that evidence has been anecdotal, often based on the perceived competence of graduates. There has been very little objective evaluation of the undergraduate dental programmes themselves, grounded in educational theory. Encouragingly, over the past 10 years and coinciding with the introduction of PBL in our dental schools, a trickle of scholarly publications on dental education in Australia has begun to appear in the literature. The findings presented in these papers and others in international refereed journals of education should serve as the basis upon which all of the schools continue to strive for improvements in their programmes so that they equip their graduates for a rapidly changing world.

What about the practicalities?

We have chosen to highlight two practical issues relating to PBL. The first relates to the broad nature of the learning environment that is established between staff and students and the second deals with more specific issues such as staff development and resources.

Prosser and Trigwell[53] have shown that there is not a direct link between the way teachers teach and design their courses and the quality of students' learning outcomes. The way in which students perceive and understand their learning environment and how these perceptions influence their approach to learning are major intervening factors. So, variation in students' perceptions and understanding about what PBL actually involves will influence the way they approach their studies and also their learning outcomes.

In a study of Australian student nurses, Duke *et al.*[54] found that few students fully understood the intended nature and purpose of their PBL programme. Indeed, Prosser[55] has pointed out that even in well-designed PBL programmes, students may still have difficulty understanding what PBL is about. He stresses the need to provide support in developing this understanding. Students should be engaged in thinking about the meaning of PBL and this should occur early in their courses. We would also argue that staff should be engaged in this same process to overcome the confusion and negativity that can be experienced when new educational approaches are introduced.

Glew[56] has recently put forward several reasons why he believes that PBL has not lived up to its promises and expectations in American medical schools. The points he raises are also relevant to Australia. Firstly, he highlights inadequate support from basic scientists who may not support the PBL approach themselves or who put greater emphasis on their research rather than teaching. Secondly, he lists poor oversight and inadequate assessment of the PBL curriculum by administrators and staff involved in its implementation. Thirdly, he believes that too much reliance is placed on using clinicians, who he claims are often ill-informed about the basic sciences or poorly motivated, as facilitators.

These practical problems are relevant to varying degrees in the Australian dental education scene, but are compounded by critical shortages of appropriately qualified full- and part-time academic staff, coupled with an acute lack of funds for the provision of appropriate physical resources for PBL. The Editor of the *Australian Dental Journal* has raised the problem of the declining numbers of academics in our dental schools and excessive teaching loads when contemplating the declining number of papers being submitted to the journal.[57] The quality of both the teaching and research activities performed within our dental schools is being severely challenged at present but we believe it is imperative that financial exigencies should not be allowed to stifle educational developments. We all need to be wary that economic considerations do not lead us back to teacher-centred, compartmentalized, lecture-based courses that may appear to be efficient in terms of time but are not supported by educational theory and research on student perceptions and rating of their experience, the quality of their learning outcomes and their performance.[58,59]

What about the future for dental education in Australia?

As we have pointed out elsewhere,[28] there is a certain irony in the fact that innovative approaches to dental education, such as PBL, are challenged to show how effective they are, while conventional approaches to teaching are usually not subjected to the same scrutiny. However, given that reflection is a central aspect of the

Table 3. Objectives achieved in the hybrid PBL BDS programme at the Adelaide School of Dentistry[42,43,63,64]

1. A much more flexible curriculum structure that can respond to changing needs and demands.
2. A reduction in contact hours compared with the former conventional programme with a positive influence on the students. However, this needs to be monitored closely.
3. A motivating contextual learning experience has been created with a good balance of theory and practice.
4. The overall aims and objectives of the programme are clearer to students
5. The students find the programme stimulating and enjoyable.
6. Students recognize they develop independent learning skills, including learning to self-assess and learn from interactions with colleagues
7. Students recognize PBL packages were preparing them for future dental practice, specifically, the packages are about patient management or learning a systematic approach.
8. Graduates are rated as demonstrating good or very good levels of performance by more than 60% of their employers for the majority of the objectives, including graduates' understanding of the scientific basis of dentistry; awareness of their personal limitations; and awareness of their moral and ethical responsibilities.

PBL approach, most proponents of PBL have accepted the challenge to evaluate what they do and to use these findings to continually review and revise their courses and programmes. We have proposed that the evaluation process should occur at a number of levels, involving students, staff, new graduates, employers and also the public.[60] Benchmarking exercises at both national and international levels should also be encouraged.[61] These investigations should target key outcomes of PBL, namely, how PBL supports students to be constructive, self-directed, and collaborative learners.[62] The results of our evaluations at the Adelaide School of Dentistry indicate that we are achieving some of our objectives.[42,43,63,64] These are summarized in Table 3 and while they seem relatively modest, they have been achieved in extremely difficult financial circumstances.

CONCLUSION

There is no doubt that effective oral health professionals of the future will need to be highly motivated life-long learners who know how to use the literature and who are able to practise evidence-based dentistry. PBL is an approach based on educational theory that aims specifically to develop these attributes. Financial restraints will probably preclude the introduction of integrated, small-group PBL programmes in Australian dental schools in the future. However, our own research and experience, and evidence from the literature, indicates that well-planned hybrid PBL programmes are likely to foster the types of knowledge, skills and attributes that dental professionals will need in the future.

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